

# Russian and Japanese Aerospace Literature

During 1997 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Microstructures from Russia and Microstructures from Japan.

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## Russian Aerospace Literature This month: *Microstructures*

**A96-35569 The formation of alpha double prime phase in Zr-Re alloys.** A. V. DOBROMYSLOV and N. I. TALUTS (Russian Academy of Sciences, Inst. of Metal Physics, Yekaterinburg, Russia), *Scripta Materialia* (ISSN 1359-6462), Vol. 35, No. 5, 1996, pp. 573-577. 7 Refs. Documents available from Aeroplus Dispatch.

The microstructure of quenched Zr-Re alloys containing 0.5, 1.5, and 2 at.% Re was investigated by X-ray diffraction analysis and optical and electron microscopy with a view to identifying the orthorhombic alpha double prime phase. It is found that, in the Zr-1.5 at.% Re alloy, the orthorhombic alpha double prime phase is formed instead of the hexagonal alpha prime phase formed in the Zr-1 at.% Re alloy. The formation of the alpha double prime phase is completely suppressed in the Zr-2 at.% Re alloy.

**A96-30583 Grain boundaries structure and mechanical properties of aluminum alloys.** N. K. TSENEV (Ufa State Petroleum Technological Univ., Russia), *Materials Science Forum* (ISSN 0255-5476), Vols. 207-209, Pt. 2, 1996, pp. 841-844. 6 Refs. Documents available from Aeroplus Dispatch.

We discuss the problem of the influence of grain boundary structure on the mechanical properties of aluminum alloys at elevated temperatures. The data indicate grain boundaries that are unique, as well as random grain boundaries. The fitting of calculation results on the contributions of different mechanisms of deformation to the total deformation of alloys with different types of grain boundaries is also given. (Author)

**A96-30582 Evolution of intergranular boundary structure during severe plastic deformation in aluminum alloys with different initial grain sizes.** N. K. TSENEV, I. R. KIZEEV (Ufa State Petroleum Technological Univ., Russia), and B. E. SELSKY (Bashkirian Scientific Research and Design Inst. of Petroleum Machine Building, Ufa, Russia), *Materials Science Forum* (ISSN 0255-5476), Vols. 207-209, Pt. 2, 1996, pp. 837-840. 4 Refs. Documents available from Aeroplus Dispatch.

We discuss the regularities of submicron-grained (SMG) structure formation: a structure with grain size of about 0.1  $\mu$  in a number of model and commercial aluminum alloys. The SMG structure was produced in the alloys by means of a strain-heat treatment, which includes ultimately large plastic deformation and fixing the initial stages of recrystallization. The alloy mechanical properties were studied at room and elevated temperatures. (Author)

**A96-30549 The formation of grain boundaries during plastic deformation of LiF single crystals.** R. KAIBYSHEV and O. SITDIKOV (Russian Academy of Sciences, Inst. of Metals Superplasticity Problems, Ufa, Russia), *Materials Science Forum* (ISSN 0255-5476), Vols. 207-209, Pt. 2, 1996, pp. 485-488. 8 Refs. Documents available from Aeroplus Dispatch.

The microstructural evolution of 100-plane-oriented LiF single crystals has been studied during plastic deformation at  $T = 1073$  K. It has been shown that plastic deformation leads to formation of low-angle grain boundaries and their transformation to high-angle ones. Further plastic deformation leads to intensive grain boundary migration after some critical strain. The type of structural changes occurring in LiF single crystals is determined by the character of the crystallographic slip. The reasons for critical strain existence, and for the transition from 'rotation' dynamic recrystallization to one of 'migration,' are discussed. (Author)

**A96-26571 Antioxidative protective coatings for carbon materials; 1995.** G. A. KRAVETSKII, V. I. KOSTIKOV, A. V. DEMIN, and V. V.

RODIONOVA (NII Grafit, Moscow, Russia), *High-temperature ceramic-matrix composites II: Manufacturing and materials development; Proceedings of the 2nd International Conference*, Santa Barbara, CA, 1995 (A96-26539 06-24), Westerville, OH, American Ceramic Society (Ceramic Transactions. Vol. 58), 1995, pp. 267-273. 7 Refs. Documents available from Aeroplus Dispatch.

Consideration is given to the application of SiC coatings onto the surface of graphite or C-C parts by CVD or CVR methods, the cracking frequently experienced by SiC coatings applied onto the surface of large-sized or intricately-shaped parts, and the application on the surface of CCM parts of refractory self-healing-in using coatings containing refractory borides and silicides. Results of investigations in these areas using slip-casting technology are presented. The comparative resistance of coatings based on titanium, zirconium, and hafnium borides is illustrated.

**A96-26383 Diffraction gratings formation on porous silicon using CO<sub>2</sub> laser.** A. DAR'JUSHKIN, V. KARAVANSKII, S. KOROVIN, V. PUSTOVOY, and K. TIMOSHECHKIN (Russian Academy of Sciences, Inst. of General Physics, Moscow, Russia), *ALT '95 International Symposium on Advanced Materials for Optics and Optoelectronics*, Prague, Czech Republic, 1995, Proceedings (A96-26376 06-74), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 2777), 1996, pp. 53-58. 3 Refs. Documents available from Aeroplus Dispatch.

A study is made of the periodic structure of a porous silicon layer exposed to two interfering coherent beams of CO<sub>2</sub> laser radiation. By using an electron microscope, the grating period is found to be about 10  $\mu$ . The temperature and pressure of porous silicon are evaluated on the basis of the existing models of optoacoustic action. Measurements of the Raman spectra of the periodic structure also indicate that high-power CO<sub>2</sub> laser radiation induces changes in the sample microstructure.

**A96-22678 Composition-structure-properties relationship and durability of modified organosilicate polymeric composite.** S. V. TCHOUPINA and L. N. KRASIL'NIKOVA (Russian Academy of Sciences, Silicate Chemistry Dept., St. Petersburg, Russia), *Polymer/inorganic interfaces II; Proceedings of the Symposium*, San Francisco, CA, 1995 (A96-22673 05-24), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 385), 1995, pp. 147-152. 13 Refs. Documents available from Aeroplus Dispatch.

The present work was aimed at the development of new organosilicate polymeric composite, based on polydimethyl phenylsiloxane/polyurethane (PDMPs/PU) miscible blend, filled with silicates and metal oxides. Considerable improvement of mechanical and corrosion-protective properties due to introduction of polyurethane has been observed. Coatings with sufficient thermostability (up to 300 C) have been obtained in the case of 20% polyurethane content, related to the amount of binders. The effects of coating heat treatment temperature and curing conditions on the adhesion of the metal/composite interface have been studied. The surface energy characteristics of this coating have been obtained and were correlated with its microstructure, determined from scanning electron X-ray microprobe analyses. Recently developed composite appeared to show increased durability in atmosphere operation conditions.

**A96-21808 Correlation lidar measurements of meteorological characteristics in conditions of atmospheric condensation.** G. G.

MATVIENKO, A. I. GRISHIN, and A. E. ZILBERMAN (Russian Academy of Sciences, Inst. of Atmospheric Optics, Tomsk, Russia), *Air pollution and visibility measurements; Proceedings of the Conference*, Munich, Germany, 1995 (A96-21754 04-35), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings, Vol. 2506), 1995, pp. 658–665. 7 Refs. Documents available from Aeroplus Dispatch.

At a lidar sounding of atmosphere meteorological parameters (wind velocity and direction profile) the precipitation is often considered as a hindrance that limits the distance and accuracy of the measurements and in some instances renders the measurements impossible. But in the course of investigations it has been found that in certain situations the precipitation increases efficiency of lidar sounding. In this case the distance and accuracy of sounding are increased. The possibility of determining the microstructure and integral characteristics of the precipitation area exists. The investigations were performed using the correlation scanning three-path lidar with a vertical sounding scheme. The study of the optical signals reflected from precipitation showed an increase of the wind velocity sounding efficiency due to amplification of the signal fluctuation components. (Author)

**A96-21552 Effect of annealing on microstructure, phase composition and failure of  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  ceramics at room temperature; 1996.** N. ORLOVSKAYA, G. KRIVOSHEJ O. BABIJ (Ukrainian National Academy of Sciences, Inst. for Problems of Materials Science, Kiev, Ukraine), and D. OSTROVOJ (Ukrainian National Academy of Sciences, Inst. for Problems of Strength, Kiev, Ukraine), *Journal of Materials Science Letters* (ISSN 0261-8028), Vol. 15, No. 2, 1996, pp. 166–169. 19 Refs. Documents available from Aeroplus Dispatch.

We investigate the effect of annealing on the strength and fracture toughness of hot-pressed alumina-zirconia ceramics, noting discrepancies in the data published to date. It is found that the structural and phase transformations in the volume and at the surface of the specimens during annealing exert great influence on the physico-mechanical properties of these ceramics.

**A96-21469 Principles of alloying and design of structure of high-temperature high-strength niobium alloys.** E. N. SHEFTEL and O. A. BANNYKH, *Tungsten and refractory metals—1994; Proceedings of the 2nd International Conference*, McLean, VA, 1994 (A96-21451 04-26), Princeton, NJ, Metal Powder Industries Federation, 1995, pp. 629–655. 12 Refs. Documents available from Aeroplus Dispatch.

The scientific principles of alloying high-temperature niobium alloys providing high strength and workability of alloys via strengthening by dispersion particles of thermodynamically stable oxides, nitrides, and carbides, as well as alloys strengthening by intermetallic compound dispersion particles, are considered. The emphasis is placed on structure designing. The latter is based on revealing the dependence between manufacturing and treatment conditions, structure, and mechanical properties of the alloys. The principles of alloying and structure designing ensures that alloys with high-temperature strength and specific high-temperature strength are superior as compared to all known niobium-base alloys. (Author)

**A96-21088 Computational modeling of structure and mechanical properties of the advanced composites.** Y. G. YANOVSKIJ and I. F. OBRAZTSOV (Russian Academy of Sciences, Inst. of Applied Mechanics, Moscow, Russia), *SDVNC'95—International Conference on Structural Dynamics, Vibration, Noise and Control*, Hong Kong, 1995, Proceedings, Vol. 1 (A96-21051 04-39), Hong Kong, Colour Max Commercial Printing Co., Ltd., 1995, pp. 400–405. 8 Refs. Documents available from Aeroplus Dispatch.

Advanced composites are heterogeneous bodies whose structure and properties depend not only on the properties of the matrix and fillers but also on various kinds of interactions between the components on their mutual arrangement and volume ratio. These factors must be considered when modeling the composite structure, mechanical properties, etc. The problem consists primarily in selecting a physically substantiated model and theory and requires a search for analytical and numerical methods of their analysis. Models with interphase layers and a set of different numerical methods and specific computer programs were developed and proposed for describing the physico-mechanical properties and strain-stress behavior of advanced polymer composites. (Author)

**A96-20920 Superplasticity and hot rolling of two-phase intermetallic alloy based on TiAl.** R. IMAYEV, M. SHAGIEV, G. SALISHCHEV, V. IMAYEV, and V. VALITOV (Russian Academy of Sciences, Inst. for Metals Superplasticity Problems, Ufa, Russia), *Scripta Materialia* (ISSN 1359-6462), Vol. 34, No. 6, 1996, pp. 985–991. 14 Refs. Documents available from Aeroplus Dispatch.

An examination is conducted of superplastic behavior of a TiAl+Ti<sub>3</sub>Al, Ti-46 at.% Al intermetallic alloy with micron and submicron grain sizes. These results are applied to the hot rolling process. Increasing quantities of alpha-2 Ti<sub>3</sub>Al is found to promote microstructural stabilization through prevention of twins-formation during heating, as well as by retarding grain growth during superplastic deformation.

**A96-12899 The effect of thermal treatment on the structure and composition of a solid solution of UC-TaC.** A. GONTAR, V. ZAITSEV, V. L. MITROFANOV, A. S. PANOV, E. V. FIVEISKY, Y. F. KHRMOV (NPO 'Luch', Podolsk, Russia), and H. H. MOELLER (Babcock & Wilcox, Lynchburg, VA), *30th Intersociety Energy Conversion Engineering Conference (IECEC)*, Orlando, FL, 1995, Proceedings, Vol. 2 (A96-12760 01-44), New York, American Society of Mechanical Engineers, 1995, pp. 265–269. 4 Refs. Documents available from Aeroplus Dispatch.

The objective of this study was to determine the compositional and microstructural stability of porous (U(0.7)-Ta(0.3))C(0.99). Pellets of (U(0.7)-Ta(0.3))C(0.99) were prepared with nominal porosities of 10 and 20% and thermally annealed in vacuum at 1873 and 2073 K for 500 h. The analyses showed that the microstructure was unaffected by the thermal exposures, remaining equiaxed and single phase. Slight variations were observed in the chemical composition of the pellets as measured by XRD and chemical analyses. (Author)

**A96-12632 Model of viscoelastic unidirectional composite with coupled thermal and elastic processes.** A. D. RESNYANSKY (Russian Academy of Sciences, Inst. of Hydrodynamics, Novosibirsk, Russia) and E. I. ROMENSKY (Russian Academy of Sciences, Inst. of Mathematics, Novosibirsk, Russia), *Shock waves at Marseille III: Shock waves in condensed matter and heterogeneous media; Proceedings of the 19th International Symposium on Shock Waves*, Marseille, France, 1993 (A96-12597 01-34), Berlin and New York, Springer-Verlag, 1995, pp. 273–278. 4 Refs. Documents available from Aeroplus Dispatch.

To analyze the shock wave processes in composite materials, a model is developed, based on the representation of the behavior of matrix and reinforcement materials as viscoelastic media. For its construction, a method was formulated of phenomenological averaging of parameters not requiring an assumption of composite structure regularity. Hypotheses proposed for the closure of the model are described in detail. The interphase nonequilibrium and the structural parameters concerned are introduced. Two-phase composites of two types are considered: fibrous one-directional ones with parallel fibers, and laminated ones with parallel laminae. The resulting system of evolution and kinetic equations for the composite macroparameters is outlined. Numerical examples illustrating the influence of high-rate nonequilibrium are shown.

**A96-12227 Thermal stability of porous pellets of a solid solution of UC-TaC.** A. S. GONTAR, V. A. ZAITSEV, V. L. MITROFANOV, A. S. PANOV, E. V. FIVEISKY, Y. F. KHRMOV (NPO 'Luch', Podolsk, Russia), and H. H. MOELLER (Babcock & Wilcox Lynchburg Research Center, VA), *Symposium on Space Nuclear Power and Propulsion, 12th; Conference on Alternative Power from Space; Conference on Accelerator-Driven Transmutation Technologies and Applications*, Albuquerque, NM, 1995, Proceedings, Pt. 1 (A96-12172 01-20), Woodbury, NY, AIP Press (AIP Conference Proceedings, No. 324), 1995, pp. 377–382. 2 Refs. Documents available from Aeroplus Dispatch.

The thermal stability of (U0.7-Ta0.3)C0.99 pellets with nominal porosities of 10 and 20% was investigated. In this study, pellets were thermally treated at 1873 and 2073 K in vacuum for 500 h. Characterization before and after testing included chemical and phase compositions, pellet dimensions, porosities, and microstructure. The results showed that the pellets exposed to 1873 K exhibited little change. The pellets exposed to 2073 K did exhibit some changes. The specimens remained single-phased but slight changes in the stoichiometry occurred. That is, the carbon and uranium content was reduced. The most significant change occurred in the porosity of the specimens exposed to 2073 K. Posttest analysis revealed that all of the specimens thermally treated at 2073 K had a final porosity in the 7–8% range. (Author)

**A95-38939 Statistical aspects of low temperature discontinuous deformation; 1995.** M. A. LEBYODKIN, L. R. DUNIN-BARKOVSKI, V. S. BOBROV, and V. GROEGER (Russian Academy of Sciences, Inst. for Solid State Physics, Moscow, Russia), *Scripta Metallurgica et Materialia* (ISSN 0956-716X), Vol. 33, No. 5, 1995, pp. 773–780. 22 Refs. Documents available from Aeroplus Dispatch.

Low temperature deformation data are reported for a commercial Cu-Be<sub>2</sub> alloy. The unstable plastic flow observed could be governed by thermomechanical instability (TMI) involving an avalanche-like deformation process in which dislocation mobility increases due to heat generated at the mobile dislocations. Macroscopic stress behavior of the discontinuous flow is analogous to the Portevin-Le Chatellier effect.

**A95-35411 The peculiarities of structure and properties formation of diamond-containing functional gradient materials in the SHS-regime.** E. LEVASHOV (Moscow Steel and Alloys Inst., Russia), *FGM 94; Proceedings of the 3rd International Symposium on Structural and Functional Gradient Materials, Swiss Federal Inst. of Technology*, Lausanne, Switzerland, 1994 (A95-35401 09-23), Lausanne, Switzerland, Presses Polytechniques et Universitaires Romandes, 1995, pp. 95–100. 5 Refs. Documents available from Aeroplus Dispatch.

Some peculiarities of diamond-containing FGM manufacturing in the self-propagating high-temperature synthesis (SHS) regime were studied. Because of the short characteristic periods that a diamond stays in the high-temperature zone of the combustion wave, it appears possible to produce new materials impregnated with diamond grains by the SHS method without application of high pressure. Conditions were found in which a diamond preserves its strength properties in the combustion wave, and a new approach to the FGM synthesis allows one to significantly raise the limit of exothermic mixture dilution by diamond and to produce a material with a diamond concentration in the layer of up to 50 vol%. The influence of the mass and composition of the diamond-free exothermic mixture layer on the method of structure formation of various SHS FGMs containing diamond was studied. FGM of the systems NiAl/(NiAl+diamond), TiB/(TiB+diamond) were produced. (Author)

## Japanese Aerospace Literature This month: *Microstructures*

**A96-36193 Ti effect on microstructure and strength of  $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$  and SiC/SiC joints brazed with Cu-Ag-Ti filler material; 1996.** T. TAMAI (Industrial Technology Center, Saga, Japan) and M. NAKA (Osaka Univ., Japan), *Journal of Materials Science Letters* (ISSN 0261-8028), Vol. 15, No. 14, 1996, pp. 1203, 1204. 3 Refs. Documents available from Aeroplus Dispatch.

An effort is made to experimentally clarify the role of Ti in brazing ceramic joints for two different compositions. The microstructures and elemental compositions of the joining layer were studied by SEM and electron probe microanalysis; joint strength was determined by four-point bending. The strength of the SiC/TiC interface in a SiC/SiC joint may be weaker than the  $\text{Si}_3\text{N}_4/\text{TiN}$  interface in a  $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$  joint.

**A96-35322 Indicators of aqueous alteration and thermal metamorphism on the CV parent body—Microtextures of a dark inclusion from Allende; 1996.** T. KOJIMA (Tokyo, Univ., Japan) and K. TOMEOKA (Kobe Univ., Nada, Japan), *Geochimica et Cosmochimica Acta* (ISSN 0016-7037), Vol. 60, No. 14, 1996, pp. 2651–2666. 55 Refs. Documents available from Aeroplus Dispatch.

An unusual dark clast in the Allende CV3 chondrite (termed Allende-AF), which was previously interpreted as a primary aggregate formed in the solar nebula was reexamined. Our study reveals abundant evidence suggesting that it probably experienced extensive aqueous alteration and subsequent thermal metamorphism on the meteorite parent body. Allende-AF contains numerous rounded to oval-shaped inclusions embedded in a dark matrix. The inclusions, consisting predominantly of fine grains of Fe-rich olivine, have internal textures suggesting that they are pseudomorphs after chondrules. Several inclusions appear to be replaced CAIs. Veins filled with fibrous olivine grains occur abundantly in both inclusions and matrix; some veins penetrate several inclusions, providing strong evidence that aqueous alteration occurred after accretion. The fibrous morphology of olivine in veins and inclusions suggests that the olivine was produced by dehydration and thermal transformation of phyllosilicate that had been formed by aqueous alteration. The wide variation in texture of dark inclusions can be explained by different degrees of aqueous alteration that preceded thermal metamorphism. (Author)

**A96-35212 Growth behavior of microstructurally short cracks in the 6061 aluminum alloy with and without 22 vol% SiC whiskers; 1996.** H. TODA (Suzuki Motor Corp., Hamamatsu, Japan) and T. KOBAYASHI (Toyoohashi Univ. of Technology, Aichi, Japan), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 27A, No. 7, 1996, pp. 2013–2021. 23 Refs. Documents available from Aeroplus Dispatch.

Short crack growth behavior of the 6061 Al alloy with and without SiC whiskers was investigated. Fluctuations in the growth rate of short cracks converge with growth of the cracks and become substantially constant between 25 and 40  $\mu$  in the MMC and 110 and 183  $\mu$  in the unreinforced alloy. This is attributed to the release of the short cracks from the microstructural effects, i.e., the interaction with reinforcement structure in the MMC and grain boundaries in the unreinforced alloy. Also, there exists a slowing down of short crack advance in the MMC, and this was explained on the basis of the rapid development of the crack closure obtained in this study. (Author)

**A96-34913 Structural changes during low energy ball milling in the Al-Ni system; 1996.** R. MARIC, K. N. ISHIHARA, and P. H. SHINGU (Kyoto Univ., Japan), *Journal of Materials Science Letters* (ISSN 0261-8028), Vol. 15, No. 13, 1996, pp. 1180–1183. 7 Refs. Documents available from Aeroplus Dispatch.

An attempt is made to provide experimental evidence to prove that the formation of  $\text{Al}_{50}\text{Ni}_{50}$  powder occurs explosively or gradually depending on the mode of heat generation and structure formation during the milling process. The formation of NiAl is determined directly from saturation magnetization measurements, since NiAl is paramagnetic and the remaining pure nickel in the multilayers is ferromagnetic. It is demonstrated that the formation of NiAl during ball milling of the elemental powders occurs either by an explosive reaction, with all particles reacting at the same time, or by a gradual explosion in individual grains. The interrupted milling in the early stage of the milling process and the easy oxidation that occurred just after the lamellar structure formation led to the first kind of reaction. In the second case, continuous milling after the formation of lamellae and the later interruption of the milling process did not lead to an abrupt explosion.

**A96-34908 Mechanical alloying in the Al-Bi alloy system.** K. UENISHI, K. F. KOBAYASHI (Osaka Univ., Japan), and K. H. YONG (Taejeon National Univ. of Technology, Republic of Korea), *Journal of Materials Science* (ISSN 0022-2461), Vol. 31, No. 13, 1996, pp. 3605–3611. 15 Refs. Documents available from Aeroplus Dispatch.

Mechanical alloying (MA) was carried out to investigate the MA behavior of the immiscible Al-10, 30 at.% Bi alloys. After the MA processing, the Al and Bi were finely and homogeneously alloyed. The Bi crystallite size decreased to 25 and 30 nm in the Al-10 at.% Bi and Al-30 at.% Bi alloys, respectively. By increasing the MA time, the hardness increased up to a value of 80 Hv, which is larger than that obtained from the rule of mixtures. The lattice parameter of Bi decreased by about 0.27%, which shows

the formation of a nonequilibrium hcp Bi super-saturated solid solution. The extended solubility of Al in Bi was 1.9% in the Al-30 at.% Bi alloy due to the extended solubility, depression of the melting temperature of hcp Bi was confirmed in the mechanically alloyed Al-Bi alloys. The maximum depression in the temperature was about 10 K. The measured values corresponded well with those estimated from the extrapolation of the solidus line. (Author)

**A96-34657 Chemical compositions of ultrafine lamellae in the water-quenched Ti-48Al alloy.** K. HONO, E. ABE, T. KUMAGAI, and H. HARADA (National Research Inst. for Metals, Tsukuba, Japan), *Scripta Materialia* (ISSN 1359-6492), Vol. 35, No. 4, 1996, pp. 495–499. 11 Refs. Documents available from Aeroplus Dispatch.

Measurements are conducted of the local chemical concentration changes across ultrafine lamellae, to elucidate the mechanism of microstructural evolution in water-quenched Ti-48 at.% Al. Atom probe field ion microscopy was used to achieve the requisite local concentration determinations for the ultrafine lamellae. It is confirmed that the lamellar structure is produced by the diffusional process.

**A96-34173 Growth and tubule formation of boron filament by electron beam heating in an electron microscope.** M. TOMITA, T. HAYASHI, S. SUZUKI, and J. TANAKA (National Inst. for Research in Inorganic Materials, Tsukuba, Japan), *ICIM/ECSSM '96: Proceedings of the 3rd International Conference on Intelligent Materials and 3rd European Conference on Smart Structures and Materials*, Lyon, France, 1996 (A96-34068 09-31), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings, Vol. 2779), 1996, pp. 833–837. 4 Refs. Documents available from Aeroplus Dispatch.

Using TEM, we have shown that an amorphous boron filament can be obtained by vapor-liquid-solid growth under intense electron irradiation (current density greater than 100 A/sq cm) on an amorphous boron nitride film deposited with a few nm of gold as an agent. The grown filaments have gold particles on the tops, and the diameters were from 10 to 100 nm. Detailed electron energy-loss spectrum analysis of the amorphous boron was carried out. We also observed a shrinking of filaments due to the evaporation of boron through the gold particles. As a special case, boron-rich tubules of several hundred-nm-diameter were also formed. (Author)

**A96-33332 Crystallography of grain boundary alpha precipitates in a beta titanium alloy.** T. FURUHARA (Kyoto Univ., Japan), S. TAKAGI (Kawasaki Steel Corp., Chiba, Japan), H. WATANABE (Kobe Steel, Ltd., Fushawa, Japan), and T. MAKI (Kyoto Univ., Japan), *Metallurgical and Materials Transactions A—Physical Metallurgy and Materials Science* (ISSN 1073-5623), Vol. 27A, No. 6, 1996, pp. 1635–1646. 31 Refs. Documents available from Aeroplus Dispatch.

The crystallography of alpha (hcp) precipitates formed on the beta (bcc) matrix grain boundaries has been studied with TEM in a Ti-15V-3Cr-3Sn-3Al alloy. The alpha precipitates have a near-Burgers orientation relationship with respect to at least one of the adjacent beta grains. Among the possible 12 variants in this orientation relationship, the variant that line-type 11-20(alpha) is parallel to the 111-line(beta) closest to the grain boundary plane tends to be preferred by the alpha precipitates. Additionally, further variant selections are made so as to minimize the deviation of the orientation relationship with respect to the 'opposite' beta grain from the Burgers one. Such rules in variant selection often result in the formation of precipitates with a single variant at a planar grain boundary. Prior small deformation of the beta matrix changes the variant of the alpha precipitates at the deformed portion of the grain boundary. It is considered that the stress field of the dislocations in the slip bands intersecting with the boundary strongly affects the variants of the alpha precipitates. Discussion of these results is based upon a classical nucleation theory. (Author)

**A96-32358 Microstructure and mechanical behaviour of 3Y-TZP/Mo nanocomposites possessing a novel interpenetrated intragranular microstructure.** M. NAWA, K. YAMAZAKI (Matsushita Electric Works, Ltd., Osaka, Japan), T. SEKINO, and K. NIHARA (Osaka Univ., Ibaraki, Japan), *Journal of Materials Science* (ISSN 0022-2461), Vol. 31, No. 11, 1996, pp. 2849–2858. 28 Refs. Documents available from Aeroplus Dispatch.

Yttria stabilized tetragonal zirconia polycrystal (Y-TZP)/0–100 vol% molybdenum (Mo) composites were fabricated by hot-pressing a mixture of Y-TZP powder containing 3 mol% yttria ( $\text{Y}_2\text{O}_3$ ) and a fine Mo powder in vacuum. This composite system possessed a novel microstructural feature composed of an interpenetrated intragranular nanostructure, in which either nanometer-sized Mo particles or equivalent-sized zirconia ( $\text{ZrO}_2$ ) particles located within the  $\text{ZrO}_2$  grains or Mo grains, respectively. The strength and toughness were both greatly enhanced with increasing Mo content for the 3Y-TZP/Mo composites, thus breaking through the strength toughness tradeoff relation in transformation-toughened  $\text{ZFO}_2$  and its composite materials. They exhibited a maximum strength of 2100 MPa and a toughness of 11.4 MPa-m<sup>1/2</sup> for the composite containing 70 vol% Mo. These simultaneous improvements in strength and toughness were determined to be the result of a decrease in flaw size associated with the interpenetrated intragranular nanostructure, and a stress shielding effect created in the crack tip by the elongated Mo

polycrystals bridging the crack tip in addition to the stress-induced phase transformation. (Author)

**A96-31956 Development of Ir-base refractory superalloys; 1996.** Y. YAMABE, Y. KOIZUMI, H. MURAKAMI, Y. RO, T. MARUKO, and H. HARADA (National Research Inst. for Metals, Tsukuba, Japan), *Scripta Materialia* (ISSN 1359-6462), Vol. 35, No. 2, 1996, pp. 211–215. 16 Refs. Documents available from Aeroplus Dispatch.

A novel class of Ir-base superalloys is proposed in which gamma-fcc and gamma-prime-L1(2) phase coherent structures similar to those of Ni-base alloys are associated with significantly higher melting points. Attention is given to the binary systems Ir-Nb, Ir-Ti, Ir-Ta, Ir-Hf, Ir-Zr, and Ir-V. Very high compressive strengths and oxidation resistance superior to those of W- and Nb-base refractory alloys are obtained for these superalloys.

**A96-30558 Theoretical and experimental studies of irradiation-induced grain boundary migration depending on orientation.** H. TAKAHASHI, N. SAKAGUCHI, N. HASHIMOTO, and S. WATANABE (Hokkaido Univ., Sapporo, Japan), *Materials Science Forum* (ISSN 0255-5476), Vols. 207–209, Pt. 2, 1996, pp. 561–564. 10 Refs. Documents available from Aeroplus Dispatch.

Fe-Cr-Ni, Ni-Si, and Ni-Al alloys were electron-irradiated using high voltage electron microscopy (1000 kV), and in situ observations were made of their structural evolution; microchemical analysis was also carried out. When the Fe-Cr-Ni alloy was irradiated, there occurred the nucleation of dislocation loops followed by voids; at the same time, grain boundary migration occurred. The compositional analysis after irradiation of an area including the migrated grain boundary indicated nickel enrichment and chromium depletion. Furthermore, the grain boundary tended to migrate toward a coarser-facing boundary plane. The same grain boundary migration and compositional change at the boundary was recognized in the Ni-Si alloy. These results suggested that boundary migration and solute redistribution are closely related to irradiation-introduced point defects flow, especially of interstitial atoms; the direction of the boundary migration depends on the relationship between the two grains. (Author)

**A96-29692 Boron carbide particles formed from an amorphous boron/graphite powder mixture using a shock-wave technique.** K. YAMADA (National Defense Academy, Yokosuka, Japan), *American Ceramic Society, Journal* (ISSN 0002-7820), Vol. 79, No. 4, 1996, pp. 1113–1116. 10 Refs. Documents available from Aeroplus Dispatch.

Boron carbide (B<sub>4</sub>C) particles with filamental, distorted ellipsoidal, plate-like, and polyhedral shapes were formed from vapor generated from an amorphous boron/graphite powder mixture with 14% starting density using a cylindrical shock-wave technique. The crystal phases of shocked compact and microstructures of the B<sub>4</sub>C particles were characterized by XRD and electron microscopy, respectively. (Author)

**A96-29682 Influence of granule character and compaction on the mechanical properties of sintered silicon nitride.** H. TAKAHASHI, N. SHINOHARA (Asahi Glass Co., Ltd., Yokohama, Japan), and K. UEMATSU (Nagaoka Univ. of Technology, Japan), *American Ceramic Society, Journal* (ISSN 0002-7820), Vol. 79, No. 4, 1996, pp. 843–848. 39 Refs. Documents available from Aeroplus Dispatch.

The influence of granule character and compaction on the mechanical properties of sintered silicon nitride was studied as a function of the pH of the spray-dry slurry. The character and the compaction behavior of the spray-dried silicon nitride granules considerably affect the mechanical properties of the sintered body. Dense and hard granules resulting from a well-dispersed slurry retained their shape in green compacts and caused numerous pore defects in the sintered body. Decreasing the slurry pH to a certain value (e.g., 7.9) caused slurry flocculation and reduced the granule density as well as the diametral compression strength of the granules. Sintered bodies fabricated with these weak granules contained fewer defects and showed a remarkable increase in strength. (Author)

**A96-29435 Atomic-scale analysis of microchemical changes in a Ni-based superalloy single crystal during creep.** T. YOSHIMURA, Y. ISHIKAWA, M. SAITO, K. HIDAKA, and T. OHASHI (Hitachi, Ltd., Ibaraki, Japan), *Materials Science Research International* (ISSN 1341-1683), Vol. 2, No. 1, 1996, pp. 13–17. 15 Refs. Documents available from Aeroplus Dispatch.

Microchemical change of a Ni-based superalloy single crystal during creep test was investigated using a position-sensitive atom probe with three-dimensional atomic-level spatial resolution. In the vertical matrix channel of the disordered gamma phase between the ordered cuboidal gamma-prime phases, the finely ordered gamma-prime phase with interconnected structure is precipitated during creep coarsening, or rafting. Rafting progresses with the growth of the fine gamma-prime precipitation and the movement of the interface between the vertical channel gamma and the cuboidal gamma-prime caused by the diffusion of constituent elements such as Al, Cr, and Ni.

**A96-29336 Transition liquid phase bonding of a Hastelloy X and the bond strength at 1173 K.** T. TOYODA and T. O. ENDO (Yokohama National Univ., Japan), *Journal of Materials Science* (ISSN 0022-2461), Vol. 31, No. 9, 1996, pp. 2461–2467. 7 Refs. Documents available from Aeroplus Dispatch.

Transition liquid phase (TLP) bonding has been conducted on a Hastelloy X using amorphous foil filler metals. The inserted fillers were made by rapid solidification of a Ni-15 percent Cr alloy containing 3–5 mass percent boron as a melting point depressant. The microstructural change with isothermal bonding time from 2.4 to 38.4 ks was examined in the bond regions by optical

microscopy and electron probe microanalysis (EPMA). An assessment of the bond strength was made by stress rupture tests performed at 1173 K. It was found that rupture strain and rupture life increased with increasing bonding time. A bond efficiency greater than 80% was achieved when the bonding time was 38.4 ks. (Author)

**A96-29005 Design and development of functionally graded material by pulse discharge resistance consolidation with temperature gradient control.** H. KIMURA (National Defense Academy, Yokosuka, Japan) and K. TODA (Koyo Seiko Co., Ltd., Osaka, Japan), *Powder Metallurgy* (ISSN 0032-5899), Vol. 39, No. 1, 1996, pp. 59–62. 8 Refs. Documents available from Aeroplus Dispatch.

A novel method of pulse electric discharge resistance consolidation with temperature gradient control has been developed for the design and fabrication of functionally graded materials (FGMs). The powder processing route employed makes it possible to select combinations of constituents with greatly different densification rates, controlling densification up to full density to produce a nanoscaled structure. A die with a specially designed outer shape makes it possible to achieve desired temperature profiles along a graded composition. Using a stepped graphite die with a temperature difference of more than 700 K within a width of 7 mm, a five layered material graded from TiAl intermetallic to partially stabilized zirconia PSZ can be fabricated. This structure shows full densification throughout its cross-section without any discontinuity and an increasing hardness from 650 HV at the TiAl nanocrystalline layer to 1560 HV at the PSZ layer, varying according to a mixture rule. (Author)

**A96-28375 Effect of heat treatment on interfacial reaction and tensile properties of aluminum-borate whisker reinforced aluminum alloys.** N. NISHINO and S.-I. TOWATA (Toyota Central R&D Labs., Inc., Aichi, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 46, No. 3, 1996, pp. 150–155. 10 Refs. Documents available from Aeroplus Dispatch.

The effect of heat treatment on interfacial reaction and tensile properties were investigated on aluminum-borate whisker reinforced age-hardenable Al-Cu-Mg-Si and Al-Cu-Si alloys. In the Al-Cu-Mg-Si alloy matrix composites, fine reaction products were formed at the whisker surfaces during solution heat treatment, which were identified to be MgAl<sub>2</sub>O<sub>4</sub>. These reaction products caused the brittle fracture of the composites by the notch effect. In addition to the deterioration of whisker by the interfacial reaction, the consumption of magnesium in the matrix led to a change of precipitation behavior. Then, Al-Cu-Mg-Si alloy matrix composites lost the age-hardenability. Therefore, the tensile strength of the T6 treated aluminum-borate whisker reinforced Al-Cu-Mg-Si alloy was similar to that of the unreinforced aluminum alloy. On the other hand, the tensile strength of the heat-treated magnesium-free Al-Cu-Si alloy matrix composites was higher than that of the unreinforced aluminum alloy. (Author)

**A96-28373 Effect of heat treatment after hot-rolling on texture and formability for 5083 alloy sheet; 1996.** J. HU, K. IKEDA and T. MURAKAMI (Tohoku Univ., Sendai, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 46, No. 3, 1996, pp. 126–137. 11 Refs. Documents available from Aeroplus Dispatch.

Effects of heat treatments after hot-rolling on subsequent cold-rolling and annealing textures, and formability for 5083 alloy sheets were investigated by means of pole figures measured with X-ray, uniaxial tension, plane strain tension, bulging and deep drawing tests. The influence of the heat-treatment temperature on precipitation and recrystallization during subsequent annealing after cold-rolling was analyzed using TEM and Vickers hardness tests. Heat treatments after hot-rolling can strengthen the texture components 123-plane/634-line and 112-plane/111-line, especially the latter. They also cause 110-plane/112-line to become weaker during the subsequent cold-rolling. During annealing above the recrystallization temperature, the heat treatments can produce a mixed texture with both stronger 112-plane/111-line and 100-plane/001-line and weaker 110-plane/112-line components. The mixture of textures has caused the limit diameter ratio of deep drawing to increase and in-plane plastic anisotropy to decrease. The improvement of formability of the alloy sheets is ascribed to both the increase of solid solution of Mn and Mg and the decrease of precipitates caused by the heat treatments after hot-rolling, and also to the evolution of textures on subsequent cold-rolling and annealing. (Author)

**A96-28372 Effects of additional elements and quenching conditions on the T1 phase precipitation in Al-1.3% Li-5.5% Cu-0.13% Zr alloys.** S. HIROSAWA, T. SATO, A. KAMIO (Tokyo Inst. of Technology, Japan), K. KOBAYASHI, and T. SAKAMOTO (Alithium, Ltd., Yokkaichi, Japan), *Japan Institute of Light Metals, Journal* (ISSN 0451-5994), Vol. 46, No. 3, 1996, pp. 119–125. 14 Refs. Documents available from Aeroplus Dispatch.

The age-hardening behavior and precipitation microstructures of Al-Li-Cu-Zr alloys containing various additional elements (Ag, Ge, Zn, Si, Mg, and Mg+Ag) were investigated using hardness measurement and transmission electron microscopy. The experimental results indicate that the addition of Mg has a pronounced effect on producing a high density of T1 (Al<sub>2</sub>CuLi) phase at aging temperatures above 400 K, resulting in the increased hardness of the alloys. In contrast, the additions of Ag, Ge, Zn, and Si to the quaternary alloy exerts no marked influence on the precipitation kinetics. Difference in quenching condition, WQ (water-quench), DQ (direct-quench), or SQ (step-quench), strongly affects the precipitation microstructures and hardness of the alloys. This is explained by taking into account the effects of both the quenched-in excess vacancies and Mg atoms. The proposed mechanism is that the excess vacancies aggregate together with Mg and Cu atoms to form Mg/Cu/vacancy complexes which play an important role in the enhanced nucleation of the T1 phase. (Author)